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Simulation Based WiFi Fingerprinting for Indoor Localization

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ABSTRACT: Indoor localization is of great importance for a range of pervasive applications, such as tracking and positioning inside buildings. Although global positioning system (GPS) works extremely well for an open-air localization, it does not perform effectively in indoor environments due to the disability of GPS signal to penetrate in-building materials. Indoor localization using inexpensive, non-dedicated wireless devices has spun great attention in the last years. Nowadays ubiquitous presence of Wi-Fi access points in offices, college campus and homes are utilized with a wifi compatible hardware device. This paper mainly focuses on an enhanced wifi indoor positioning system using hardware device. Here we propose a technique to determine the position of users in indoor areas based on Wi-Fi signal strengths from access points (AP) within the indoor vicinity. The percentage of signal strengths obtained from Wi-Fi analyzers in a hardware device were used to find the location from a predetermined database. Here we use Nearest Neighbour Algorithm for finding the location of user from received RSSI value.

KEYWORDS: Access Points (AP), Nearest Neighbor Algorithm, RSSI (Received Signal Strength Indicator), Wifi fingerprinting.

I.INTRODUCTION

Location based services are becoming an important part of life for positioning and tracking. Wide adoption of GPS in mobile devices, combined with cellular networks, has practically solved the problem of outdoor localization needs. But GPS radio waves are difficult to pass through the walls and ceilings of buildings. Moreover, GPS is only able to locate devices as accurate as approximately 10 meters. As a consequence, indoor scenarios require an alternate positioning technique. As part of Location based services, indoor location awareness is important for such fields as ambient intelligence, assisted daily living, behavior analysis, social interaction studies etc. For example, people might need to navigate through a public building like a mall or hospital or college campus. It can be hard to find your way in such a building for reaching a destination or to track a person inside the building. A system that would help you navigate from one room to the next would be very helpful. Also this system can be used to locate a person inside campus and also monitoring of patients in hospital. For locating services, the indoor positioning system can help the visitor to find the point of interest inside a building.

Using handheld devices equipped wifi adapter with a wireless network based positioning system is a good choice. The widespread availability of wireless nodes is possible to utilize the networks for wireless location purposes as well. Here a wifi adaptable hardware was used for positing the user inside room. Presence of user was obtained as zones by dividing room into a sector of 8. A simulation level model was created from available signal strength of user hardware device and signal strength stored in a radio map for the execution of KNN algorithm to find the possible zone of user.

II. RELATED WORKS

There are many indoor and outdoor methods have been developed for positioning. For indoor environments, infrared, ultrasonic, Zigbee, GSM, Wi-Fi and RFID are commonly used technologies while in case of outdoor scenarios, GPS and Cell Tower Localization are the mostly employed [1][2] . GPS is the most popular and widely used positioning technology that provides location information obtained by signals sent from group of satellites. GPS can

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provide users locations very accurately but its signals are often blocked and absorbed by walls or other obstacles at indoor scenarios. Rosums TV-GPS is an enhanced positioning technique, which works both indoor and outdoor scenarios. It uses the Time Difference of Arrival (TDOA) approach applied to TV signals to estimate the position. As said in [2], it needs additional hardware for television transmitter towers to achieve precise and proper time synchronization between transmitters and receivers. Another interesting localization approach is Japans Indoor Messaging System (IMES), which is an important part of the regional Quasi-Zenith Satellite System (QZSS) project. It uses GPS signals and provides precise positioning because it employs terrestrial transmitter equipments and beacons to assist the whole localization process [3]. All the above mentioned localization systems are not suitable for proposed method, which is mentioned in this paper. The motivation is linked to three main factors: (i) the high cost of the network infrastructure for metropolitan-scale coverage; (ii) the necessity of additional modules for mobile devices, which increases implementation costs; (iii) to develop a multipurpose system which can be used as an ID card and for tracking inside campus rather than going for a smartphones for positioning system. A large number of handheld devices now have Bluetooth functionality, but it always takes a long time to read signal values, which is not practical for a mobile positioning system. Positing using RFID is another promising filed for indoor positioning, but Active RFID receivers are very expensive [4]. Wi-Fi is a ubiquitous technology that is broadly accepted by users and they are freely available nowadays. It represents a cost efficient and reliable technique that indoor positioning services can employ. Analysis of the current signal measurement methods included, the angle of arrival (AoA), received signal strength (RSS), time of arrival (ToA) and time difference of arrival (TDoA). The techniques of AoA, ToA, TDoA require a degree of time synchronization that is difficult to achieve using inexpensive off-the shelf WLAN hardware [5]. However, RSS indicating capable equipment is widely available in Wi-Fi devices. Utilizing existing WLAN infrastructure by reading RSS is a cost effective solution for this problem. Wi-Fi fingerprinting is a localization technique used for positioning with wireless access points is based on measuring the intensity of the Received Signal Strength [6].So this paper mainly explains wifi fingerprinting technology for indoor positioning by using a hardware rather than smartphones .

III.SYSTEM DESCRIPTION

A positioning component is usually needed in a LBS application to determine the location of user's wifi device. Indoor Location recognization (ILR) is a network of device used to locate objects or people inside a building wirelessly. Instead of using satellites, an ILR relies on nearby anchors (nodes/wifi access point with a known position) and applies the Wi-Fi fingerprinting technique.

3.1. Proposed System:

The proposed system mainly consists of wifi device, server (computer) and wifi modules. The wifi device consists of wifi (ESP8266), battery and controller, for obtaining signal strengths from nodes and to transmit them to server. Fig.1. On server side we need to implement algorithm (KNN algorithm) for that we need to store the trained values of Wi-Fi scanned results and able to compare the incoming values with the trained values during prediction mode to identify the location.

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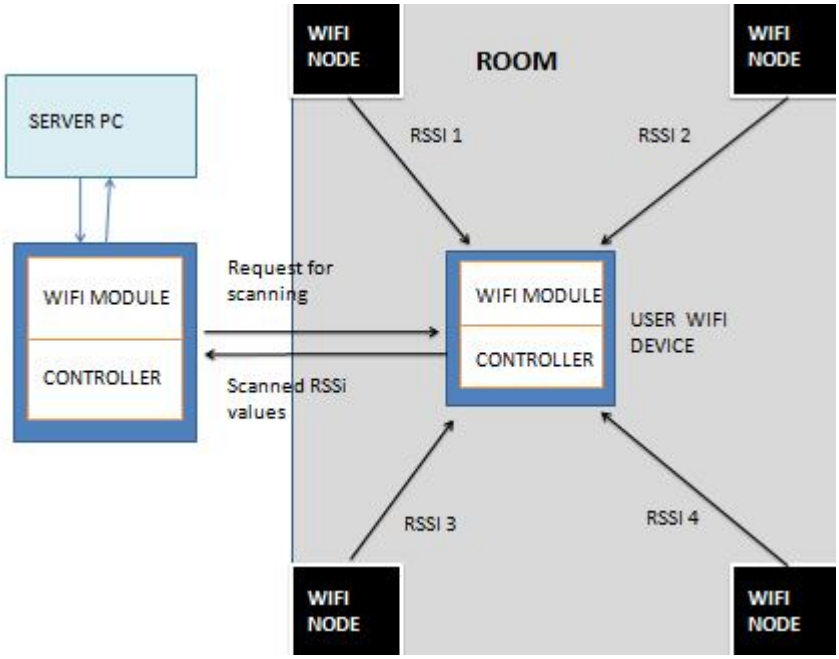

Fig.1. Proposed System

3.2. Working:

General working of Indoor localization system mainly comprise of two stages. First stage is an offline stage in which we create a radio map of RSSI values. In second stage (Online stage) we compare these RSSI values with strength obtained from an unknown position. The two stages to carry out the Indoor Location Recognization technique are explained below.

a) Training mode (calibration phase)
b) Location-identification mode (positioning phase)

3.2.1. Training Mode(Calibration Phase):

This is the initial step of indoor location recognization performed only once. Before starting the trainer mode we need a prerequisite like wifi enabled hardware device and it should be able to scan minimum 3 access points RSSI values inside the building in-order to get the more accuracy in finding the location. In training mode the trainer first scan for the available number access points in particular location. If he can't able to find the enough access points then scanning is failed for that particular location then you should changed to other location where smart-phone can able to find the enough access points, once you get the enough access points, read the RSSI values of those access points, while reading you have to take 360 degree rotation because RSSI values may vary for same location when we stand in different directions then we need to take the average RSSI value for that location along with SSID of access points and send it to server.

3.2.2. Location-Identification Mode:

In these we are actually finding a location using the trained data and current Data. The trained Data is the one which is uploaded by the trainer to the server (Radio map), the current data could be the RSSI value from the user. The nearest node is obtained used KNN algorithm.

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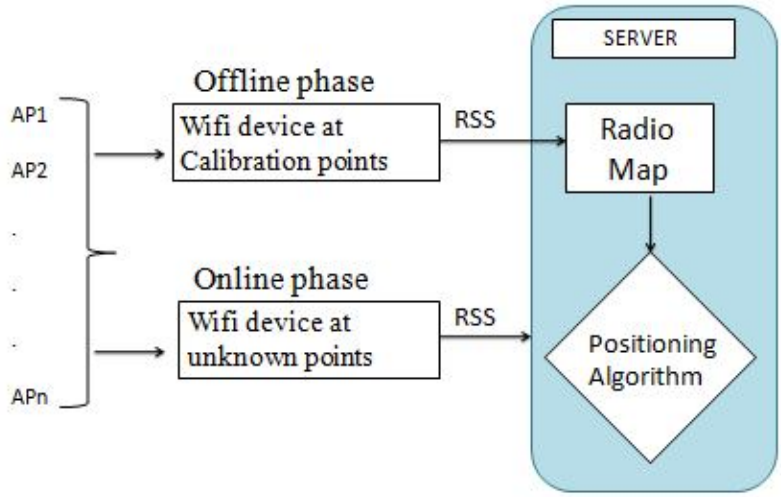

Fig.2.Positioning Flow Diagram

3.3. Positioning Algorithm:

The unknown location of a user can be estimated based on the Enhanced Radio Map by using the adapted version of the Euclidean distance algorithm and k-Nearest Neighbour algorithm. Here KNN algorithm (K- Nearest Neighbour) is used for Indoor positioning. KNN algorithm is the main machine learning based algorithm to determine user's current indoor location based on WiFi signal strength. It is a non- parametric method for classifying objects based on closest training examples in the feature space. With a proper amount of learning approach on a certain floor of a certain building, we can get some clusters based on WiFi signal signatures. From this, the system will get the WiFi signal strength and calculate estimated location of the user.

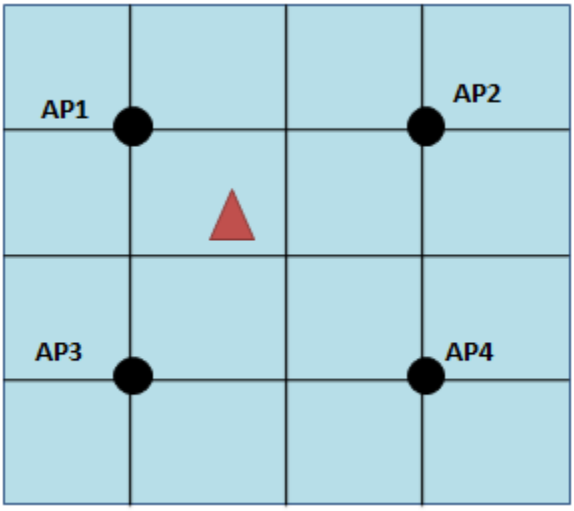

Fig.3. KNN Algorithm

The algorithm on how to compute the K-nearest neighbours is as follows:

- Determine the parameter K = number of nearest neighbors. (Generally it is selected as two).

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- Calculate the distance between the unknown node and all the training samples. This can be done by any distance algorithm.
- Sort the distances for all the training samples and determine the nearest neighbor based on the K-th minimum distance.
- Get all the categories of your training data for the sorted values which fall under K.

The Euclidean distance algorithm measures the smallest distance between points in an n dimensional space given by their respective coordinates. It is calculated by summing up the absolute distance for each dimension. The Euclidean Distance algorithm is employed to get a list of Euclidean distances between the user and Reference Points in an Enhanced Radio Map. Searching through the list of Euclidean distances between the user and Reference Points, we can find the k closest Reference Points; those Reference Points are the k-nearest neighbour. We mark them as N neighbour. The adapted k-nearest neighbour algorithm is used to estimate the possible location of an unknown user position. We use k nearest neighbour, because, sometimes there might be several Access Points that have the same distance to the user. As Fig.3 shows, AP1, AP2, AP3 and AP4 are the k nearest neighbour to the user (red triangle). If we simply assume the location of AP1, which has the shortest distance to user, to be the location, then the error distance will increase. So averaging over the location of AP1, AP2, AP3 and AP4 we can get a better estimation of user location.

IV.RESULTS

One of the important factors is to obtain an accurate position of user from the received signal strength. The comparison of RSS of user with a predetermined database, or radio map was simulated using matlab Fig.4. A positioning algorithm - KNN algorithm was implemented using matlab. Positioning inside a room was made by dividing it into zones and positing of user was estimated in a zone level. Initially a ground plan of the rooms was created. RED CIRCLE represent points where the RSS values that are predetermined and saved as a database (Radio map). YELLOW TRIANGLE represents position in which the user occupies. KNN algorithm will compare the RSS with the database and obtain a nearest value as user position.

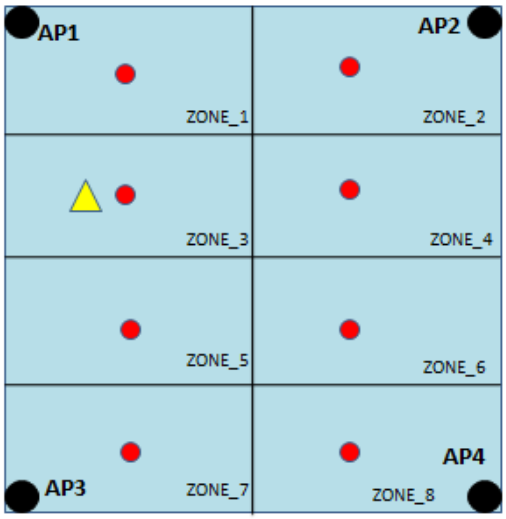

Fig.4. Simulation Results in Matlab

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V. CONCLUSION AND FUTURE WORKS

Indoor localization is a promising field in recent years mainly for indoor navigation and positioning. This paper mainly implements a methodology for indoor based position location using wifi fingerprinting and an algorithm for finding nearest node using KNN algorithm in matlab .This system can overcome limitations of GPS. Further works are for making the system more effective for a whole building of college and for minimizing error in localization.

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